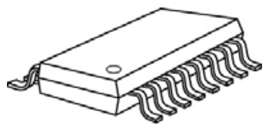
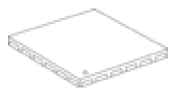
PWM Embedded 3-Channel Constant Current LED Sink Driver for RGB LED Clusters

Shrink SOP



GP: SSOP16L-150-0.64

QFN



GFN: QFN24L-4*4-0.5

Features

- 3-channel constant current LED sink driver for RGB LED clusters
- Constant output current range per channel: 5~150mA
- Excellent output current accuracy,
  - Between channels: <±3% (max.);
  - Between ICs: <±3% (max.)
- Sustaining voltage at output channels: 40V (max.)
- Embedded 16-bit PWM generator
  - Gray scale clock generated by the embedded oscillator, GCLK: 9MHz or 4.5MHz
  - Patented S-PWM technology to improve the visual refresh rate
- Two selectable modes for color enrichment and correction
  - 16-bit gray scale mode
  - 10-bit gray scale mode (with optional 6-bit dot correction)
- Reliable data transmission
  - Daisy-chain topology
  - Two-wire only transmission interface (patent pending)
  - Clock re-generation to recover the clock duty cycle
  - Selectable innovative cross-reference interface (patent pending)
- Supply voltage range (V_{DDH}): 7~30V
- Supporting 5V power system (V_{DDL})
- Embedded voltage regulator
  - Providing 5V power supply for peripheral devices when sufficiently biased
- Acting as a PWM controller with selectable polarity reversion to drive external high-power drivers or MOS
- RoHS-compliant packages

Application

- Architectural lighting
- LED curtain display or LED strip
- Neon light replacement
- Channel letter
- Remote PWM generator

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Product Description

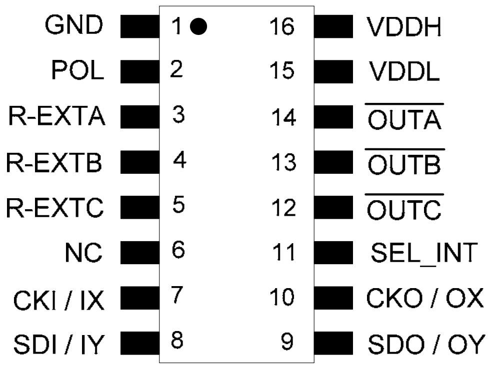
MBI6030 is a 3-channel, constant current, PWM-embedded LED sink driver for RGB LED cluster. MBI6030 provides constant current ranging from 5mA to 150mA for each output channel and sustains 40V at output channels. The constant output current of each output channel is adjustable with three corresponding external resistors.

By S-PWM technology, MBI6030 scrambles the 16-bit PWM cycle into 64 segments to enhance the visual refresh rate up to 64 times of the original frame rate, when GCLK, the gray scale clock generated by the embedded oscillator, frequency is 9MHz. MBI6030 also provides two selectable gray scale modes: 16-bit gray scale mode and 10-bit gray scale mode. 16-bit gray scale mode provides 65,536 gray scales for each LED to enrich the color; on the other hand, 10-bit gray scale mode provides 1,024 gray scales. However, in 10-bit gray scale mode, users may flexibly adopt 6-bit dot correction to adjust each LED by 64-step dot correction to calibrate the LED brightness.

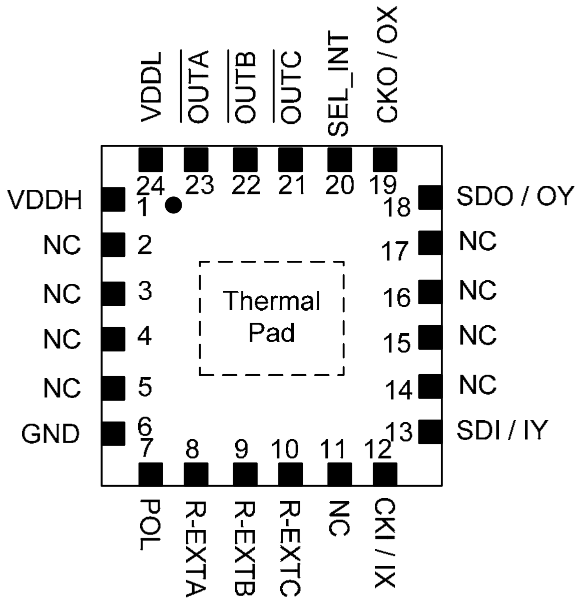
Furthermore, MBI6030 features a two-wire only transmission interface to simplify the system controller design. To improve the transmission quality, MBI6030 provides clock regeneration to recover the clock duty cycle to avoid signal distortion after long-distance transmission. In addition, MBI6030 adopts an innovative cross-reference interface (IX/IY) to reduce common mode noise, so that MBI6030 can support longer transmission distance.

MBI6030 allows wide supply voltage range (V_{DDH}) from 7V to 30V, which is suitable for 12V or 24V systems, or MBI6030 can support 5V power system (V_{DDL}). With the embedded voltage regulator, MBI6030 can also provide 5V power supply for peripheral devices when sufficiently biased. Additionally, MBI6030 preserves selectable polarity reversion to driver external high-power drivers as a PWM controller.

Pin Configuration



MBI6030GP



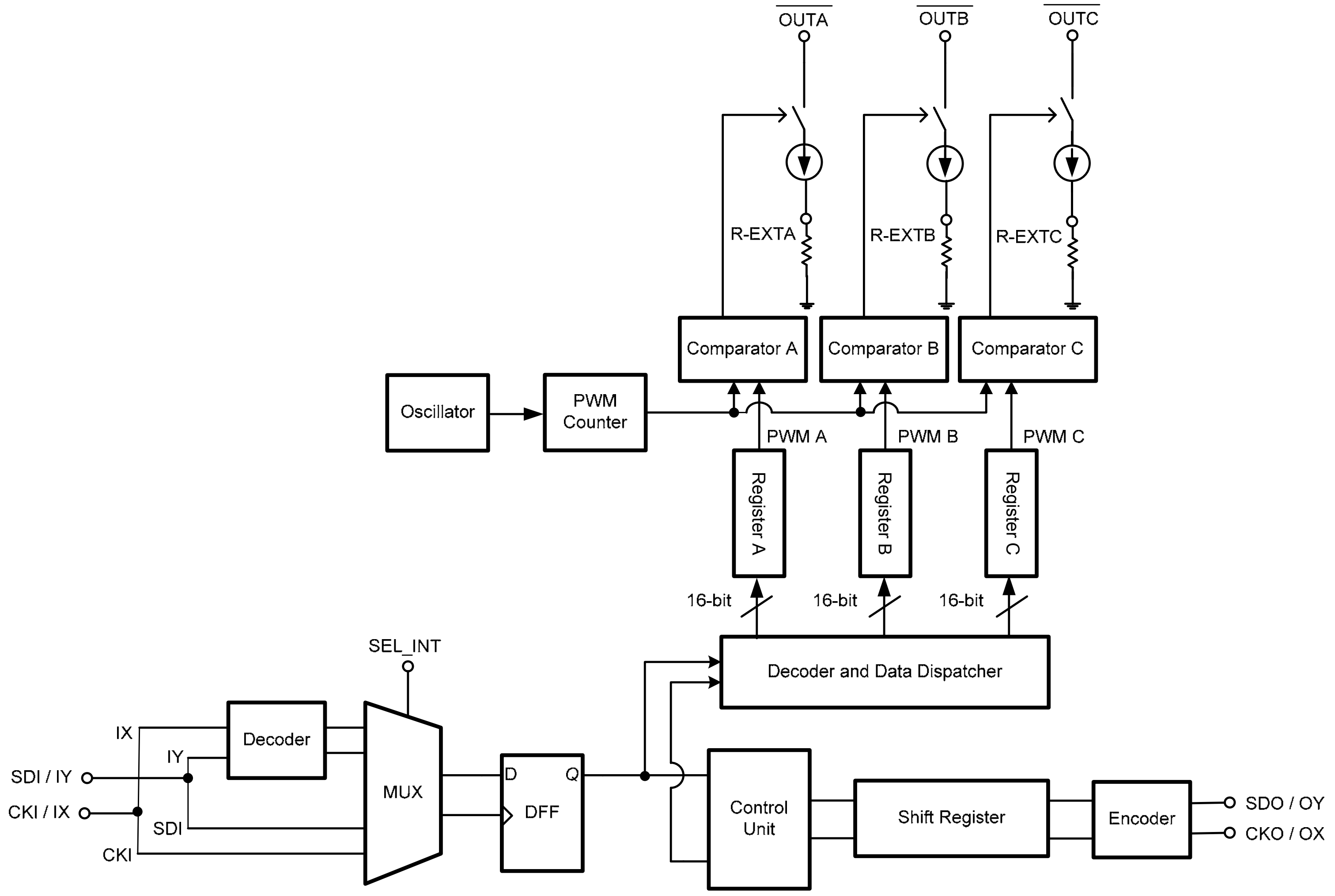
MBI6030GF

Terminal Description

Pin No.		Pin Name	Function
GP	GFN		
1	6	GND	Ground terminal.
2	7	POL	Input terminal for selecting output polarity. With internal pull-up resistor connected to VDDL. High / NC: normal mode, or to drive low-active regulators or PMOS. Low: output reversed, to work as a PWM controller to drive high-active regulators or NMOS.
3,4,5	8,9,10	R-EXTA,B,C	Input terminal for setting output current by connecting to an external resistor.
14,13,12	23,22,21	$\overline{\text{OUTA,B,C}}$	Output terminals for constant current output
6	2,3,4,5,11, 14,15,16,17	NC	Internal pull-down. Keep un-connected.
11	20	SEL_INT	Input terminal for selecting interface type. Internal pull-down. NC: SPI-like interface. Connected to VDDL: cross reference interface.
7	12	CKI / IX	Input terminal for clock input (CKI) or input interface channel X (IX).
8	13	SDI / IY	Input terminal for serial data input (SDI) or input interface channel Y (IY).
10	19	CKO / OX	Output terminal for clock output or output interface channel X (OX).
9	18	SDO / OY	Output terminal for serial data output (SDO) or output interface channel Y (OY).
15	24	VDDL	Bidirectional voltage regulator output for internal or external use. Connecting a capacitor to GND to enhance the stability of VDDL. When VDDH is sufficiently biased, VDDL can also supply 5V to peripheral devices.
16	1	VDDH	High supply voltage terminal.

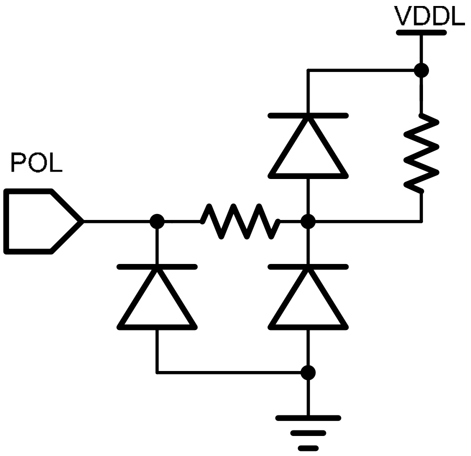
Note: Please refer “Operation Principle” section for detailed operation of IX/IY interface.

Block Diagram

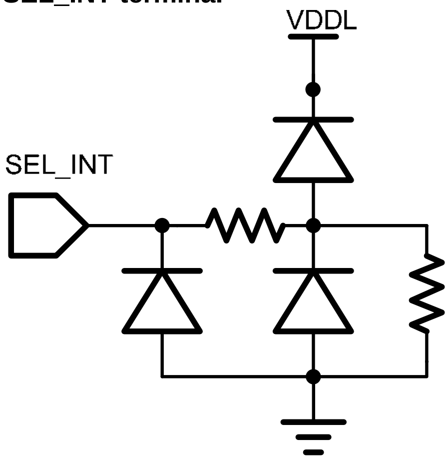


Equivalent Circuits of Inputs and Outputs

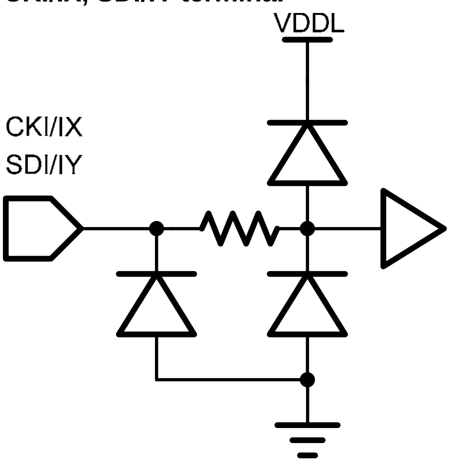
POL terminal



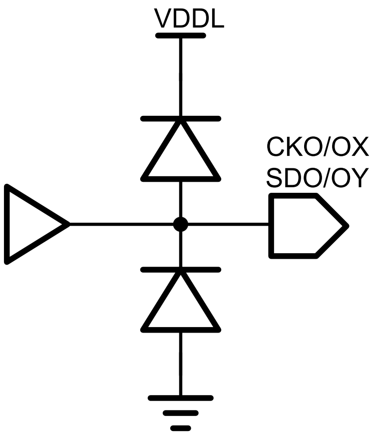
SEL_INT terminal



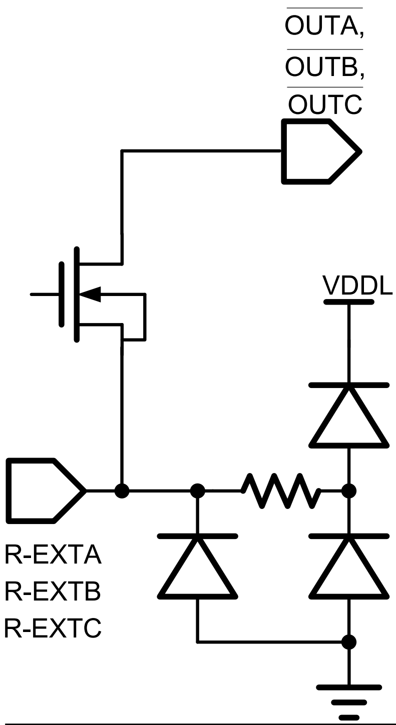
CKI/IX, SDI/IY terminal



CKO/OX, SDO/OY terminal



$\overline{\text{OUTA}}$, $\overline{\text{OUTB}}$, $\overline{\text{OUTC}}$
R-EXTA, R-EXTB, R-EXTC terminal



Maximum Ratings

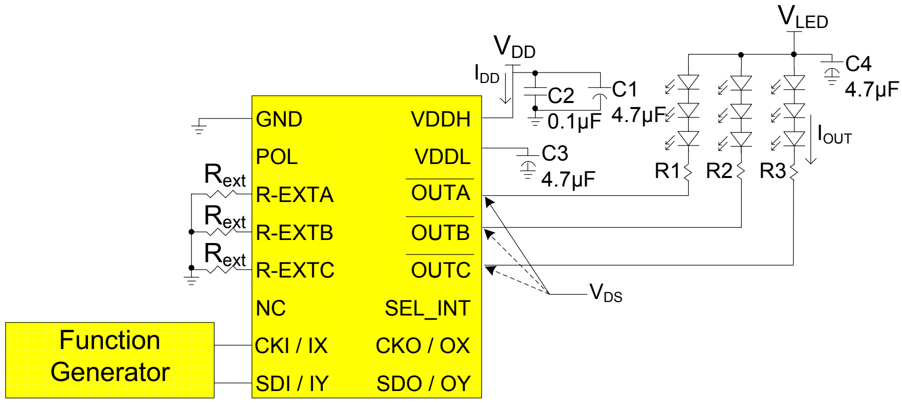
Characteristic		Symbol	Rating	Unit
Supply Voltage		V_{DDH}	0~35	V
Supply Voltage		V_{DDL}	0~7	V
Logic Input Voltage		V_{IN}	$-0.4 \sim V_{DDL}+0.4$	V
Output Current per Output Channel		I_{OUT}	+170	mA
Sustaining Voltage at OUT port		V_{DS}	-0.5~+40	V
GND Terminal Current		I_{GND}	480	mA
Power Dissipation (On PCB, Ta=25°C)	MBI6030GP	P_D	1.85	W
	MBI6030GFN	P_D	2.97	W
Thermal Resistance (On PCB, Ta=25°C)	MBI6030GP	$R_{th(j-a)}$	67.44	°C/W
	MBI6030GFN		42.10	°C/W
Operating Junction Temperature		$T_{j,max}$	150	°C
Operating Temperature		T_{opr}	-40~+85	°C
Storage Temperature		T_{stg}	-55~+150	°C
ESD Rating	Human Body Mode (MIL-STD-883G Method 3015.7)	HBM	Class 3A (4KV ~ 7999V)	-
	Machine Mode (JEDEC EIA/JESD22-A115)	MM	Class C (≧400V)	-

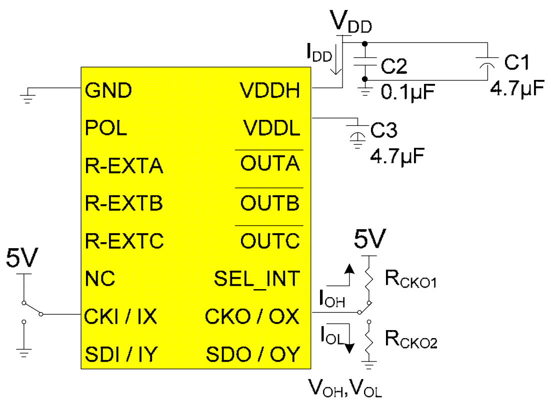
Electrical Characteristics (Ta=25°C)

Characteristic	Symbol	Condition	Min.	Typ.	Max.	Unit
Voltage Regulator Input Voltage	V_{DDH}	-	7	-	30	V
Voltage Regulator Output Voltage	V_{DDL}	V_{DDH}=12V, source 30mA	4.5	5	5.5	V
Sustaining Voltage at OUT Ports	$V_{DS,Max}$	$\overline{OUTA}$ ~ $\overline{OUTC}$	-	-	40	V
Output Current	I_{OUT}	Refer to “Test Circuit for Electrical Characteristics”	5	-	150	mA
Output Leakage Current	I_{OUT}	V_{DS}=40V, all channels turn off	-	-	0.2	μA
Output Supply Current	I_{DDO}	V_{DDH}=12V	-	8	-	mA
Output Supply Current	I_{DDO}	V_{DDH}=24V	-	16	-	mA
Current Skew (Channel)	dI_{OUT1}	I_{OUT}=19.9mA, V_{DS}=1.0V; R_{ext}=20Ω	-	±1.5	±3.0	%
Current Skew (IC)	dI_{OUT2}	I_{OUT}=19.9mA, V_{DS}=1.0V; R_{ext}=20Ω	-	±1.5	±3.0	%
Output Current vs. Output Voltage Regulation	%/dV_{DS}	V_{DS} within 1.0 V and 3.0V	-	±0.1	±0.15	% / V
Output Current vs. Voltage Regulator Input Voltage Regulation*	%/dV_{DDH}	V_{DDH} within 6.5V and 30V	-	±0.2	±0.5	% / V
Output Current for Logic Output	I_{OH}	CKO/OX, SDO/OY, at V_O=3.5V	-	-19	-	mA
Output Current for Logic Output	I_{OL}	CKO/OX, SDO/OY at V_O=1.5V	-	19	-	mA
Input Voltage for CKI/IX, SDI/IY “H” level	V_{IH}	Ta = -40~85ºC	0.7xV_{DD}	-	V_{DD}	V
Input Voltage for CKI/IX, SDI/IY “L” level	V_{IL}	Ta = -40~85ºC	GND	-	0.3xV_{DD}	V
Output Voltage for CKO/OX, SDO/OY “H” level	V_{OH}	I_{OH}=-1.0mA	-	-	0.2	V
Output Voltage for CKO/OX, SDO/OY “L” level	V_{OL}	I_{OL}=+1.0mA	4.5	-	-	V
Voltage at R-EXTA, R-EXTB, R-EXTC Pins	V_{REXT}	R_{ext}=20Ω	0.376	0.4	0.424	V
Threshold Temperature for Thermal Shutdown	T_X	POL=high: I_{OUT}=off (1CH=5mA)	-	155	-	℃
Threshold Temperature for Thermal Shutdown	T_X	POL=low: I_{OUT}=on (1CH=5mA)	-	155	-	℃
Threshold Temperature for Thermal Shutdown Recovering	T_{RECV}	POL=high: I_{OUT}=on (1CH=5mA)	-	125	-	℃
Threshold Temperature for Thermal Shutdown Recovering	T_{RECV}	POL=low: I_{OUT}=on (1CH=5mA)	-	125	-	℃
Pull-up Resistor of POL	R_{IN}(up)	POL	-	470	-	KΩ
Pull-down Resistor of SEL_INT	R_{IN}(down)	SEL_INT	-	470	-	KΩ
Supply Current	I_{DD}(on) 1	R_{ext}=20.65Ω, $\overline{OUTA}$ ~ $\overline{OUTC}$ =On	-	3.2	-	mA
Supply Current	I_{DD}(on) 2	R_{ext}=6.8Ω, $\overline{OUTA}$ ~ $\overline{OUTC}$ =On	-	3.6	-	mA

* One channel turns on.

Test Circuit for Electrical Characteristics





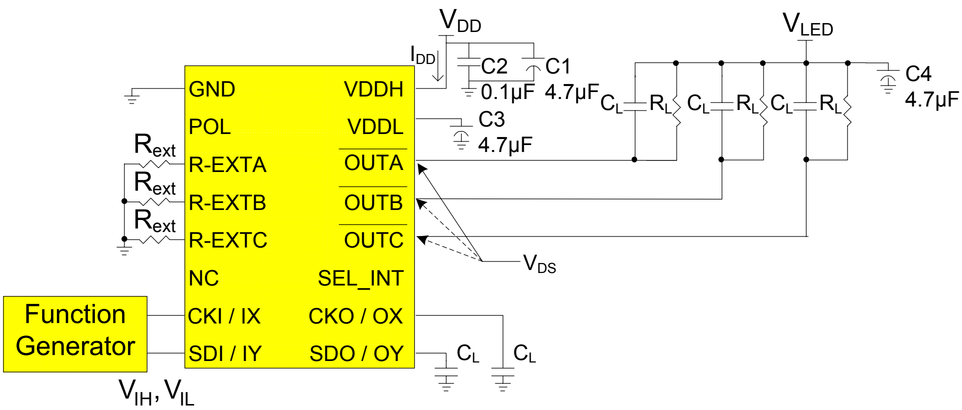
Switching Characteristics

Characteristic			Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time 1	CKI – CKO		t_{P1}	T_A=25°C, V_{DD}=12V, V_{DS}=1V, V_{IH}=4.5V, V_{IL}=0.5V, R_{ext}=20Ω (I_{OUT}=20mA), R_L=200Ω, C_L=10pF	-	25	-	ns
	IX/IY – OX/OY		t_{P1}		-	60	-	ns
Propagation Delay Time 2	CKO↑ - SDO		t_{P2}		-	2	-	ns
Pulse Width	CKO/OX, OY		$t_{w(O)}$			30	40	ns
	CKO/OX, OX/OY		$t_{w(I)}$		30	-	-	ns
Output Rise Time of Output Ports	CKO/OX, OX/OY		t_{cr}		-	2.5	-	ns
	$\overline{OUTA}$ ~ $\overline{OUTC}$		t_{orh}*		-	60	-	ns
			t_{orl}*		-	125	-	ns
Output Fall Time of Output Ports	CKO/SDO, OX/OY		t_{cf}		-	2.5	-	ns
	$\overline{OUTA}$ ~ $\overline{OUTC}$		t_{ofh}*		-	40	-	ns
			t_{ofl}*		-	135	-	ns
Hold Time	SDI-CKI↓		$t_{H(D)}$		5	-	-	ns
Setup Time	CKI↓-SDI		$t_{S(D)}$		5	-	-	ns
Frequency	IX IY**		$F_{IX, IY}$		-	-	10	MHz
	CKI**		F_{CKI}		-	-	10	MHz
	GCLK	High-frequency	F_{GCLK}		8.1	9.0	9.9	MHz
		Low-frequency	F_{GCLK}		4.0	4.5	5.0	MHz
Maximum CKI Rise Time			t_r		-	-	500	ns
Maximum CKI Fall Time			t_f		-	-	500	ns

*t_{orh}, t_{ofh} are for the high-frequency GCLK. t_{orl}, t_{ofl} are for the low-frequency GCLK.

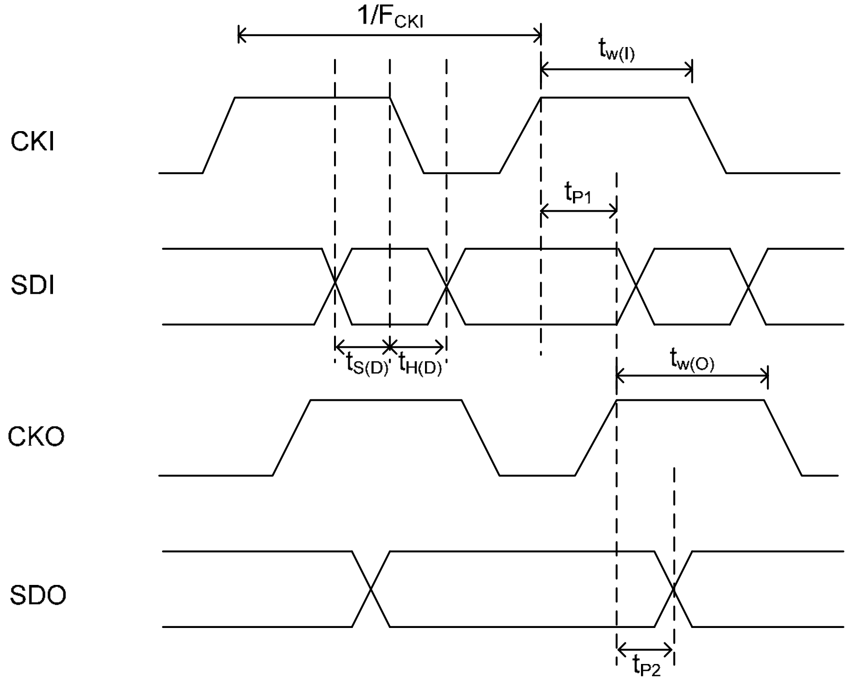
**The maximum frequency may be limited by different application conditions. Please refer to the application note for details.

Test Circuit for Switching Characteristics

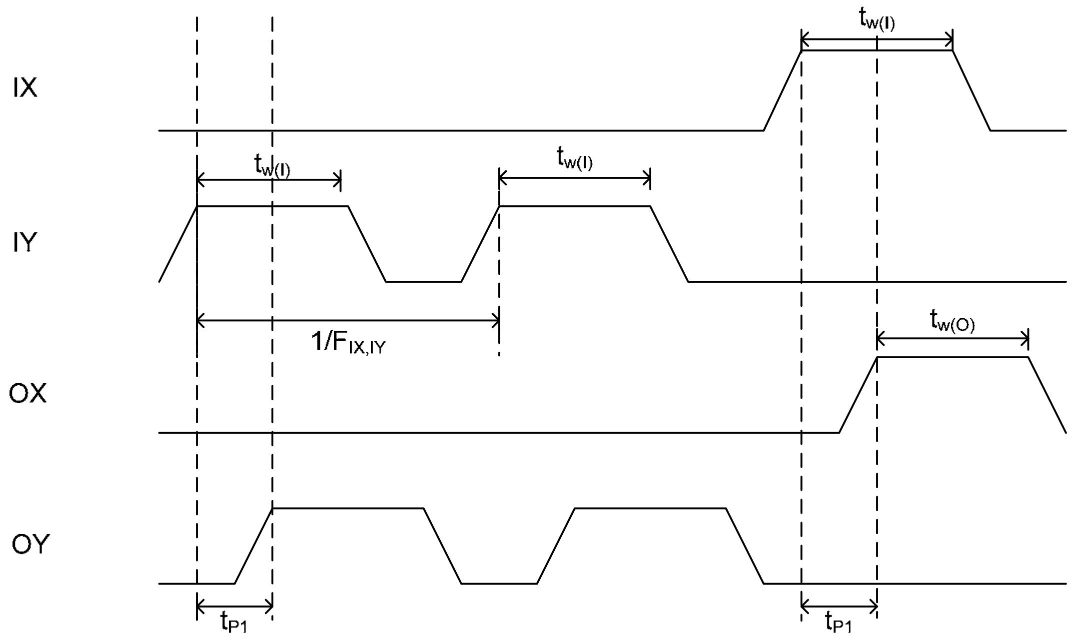


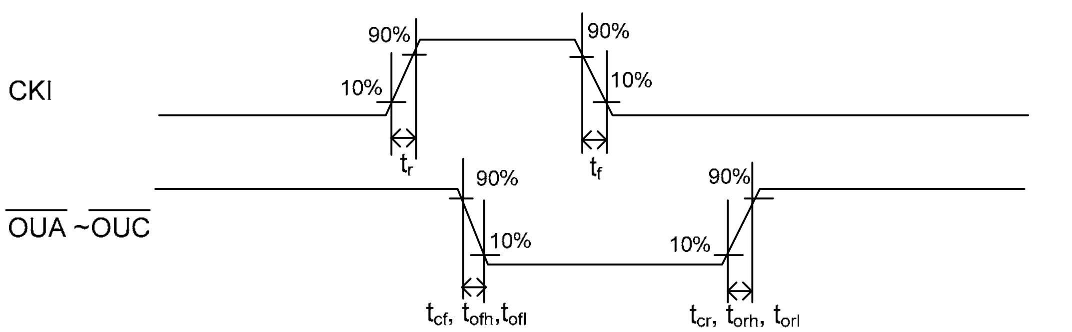
Timing Waveform

SPI-Like Interface



Cross-Reference Interface





Operation Principle

Control Method

Featuring a two-wire only transmission interface, MBI6030 allows users to choose either SPI-like interface or cross-reference interface by "SEL_INT" pin to address the image data of each LED driver accurately. The following paragraphs explain the principles of the two interfaces by a two-wire only transmission interface.

Control interface 1: SPI-like interface (CKI, SDI)

When "SEL_INT" pin is unconnected, MBI6030 will adopt the SPI-like interface (CKI/SDI). By SPI-like interface, MBI6030 samples the data (SDI) at the falling edge of the clock (CKI).

Control interface 2: cross-reference interface (IX, IY)

When "SEL_INT" pin is connected to "VDDL" pin, MBI6030 will adopt the cross-reference interface. The system controller generates IX/IY from data (SDI) and clock (CKI) based on the logic relationship of clock, data, IX and IY as shown in the following formula:

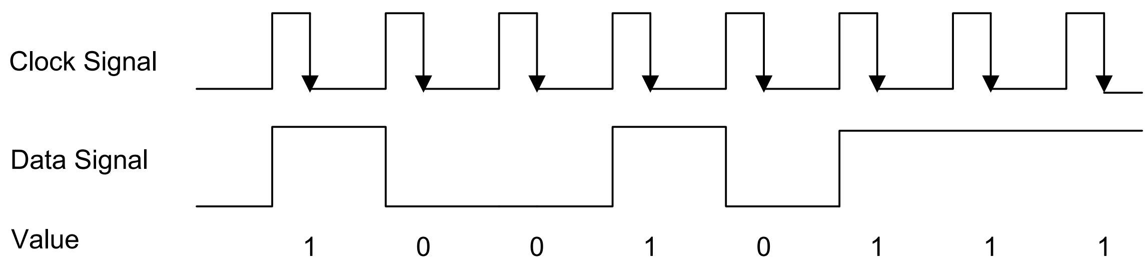
IY=data&clock

IX=(! data)&clock

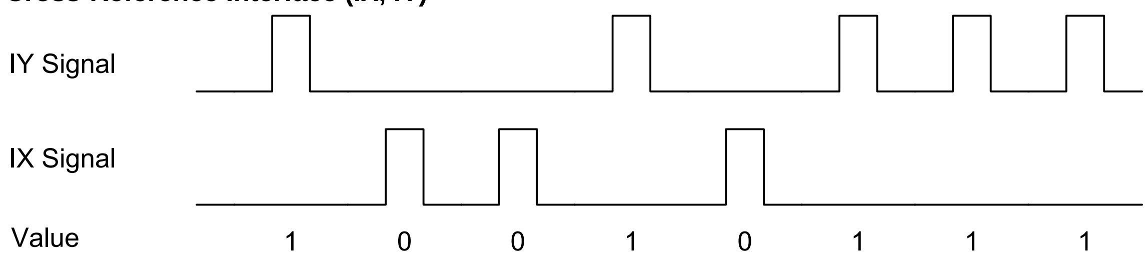
MBI6030 thereafter reads the input gray scale data through IX/IY and simply compares the signal difference of IX/IY to decode the data. Then, MBI6030 encodes again and sends the data through OX/OY to next MBI6030. By cross-reference interface, MBI6030 reduces the common mode noise. Therefore, MBI6030 can transmit longer distance by cross-reference interface than by SPI-like interface.

The following waveforms are the examples of the SPI-like interface and the cross-reference interface.

SPI-Like Interface (CKI, SDI)



Cross-Reference Interface (IX, IY)



Time-out alert disconnection

If the CKI stops for more than eight cycles, MBI6030 may identify the wires as disconnection. For cross reference interface (IX/IY), MBI6030 will also identify the wires as disconnection if both IX and IY stop for more than eight cycles. To prevent from misreading, MBI6030 will ignore the present input data and continuously show the previous image data until the next image data is correctly recognized.

GCLK Frequency

MBI6030 provides two kinds of GCLK frequency for different applications: high-frequency GCLK and low-frequency GCLK. Users can set the GCLK frequency by the bit “s” in the header of the input data stream. When bit “s” is “1”, MBI6030 works at high-frequency GCLK; when bit “s” is “0”, MBI6030 works at low-frequency GCLK.

High-frequency GCLK

In the high-frequency GCLK, the rising time and falling time of output ports (t_{Orh} ,,t_{Ofh}) and the PWM clock (F_{GCLKH}) are set as high frequency. The high-frequency GCLK is 9MHz±10%, which has twice visual refresh rate of the low-frequency GCLK.

Low-frequency GCLK

In the low-frequency GCLK, the rising time and falling time of output (t_{Orl} ,,t_{Ofl}) and the PWM clock (F_{GCLKL}) are set as low frequency. The low–frequency GCLK is 4.5MHz±10%, which can induce lower EMI and keep output current uniform at large output current.

Setting the Gray Scale

MBI6030 provides two selectable gray scale modes: 16-bit gray scale mode and 10-bit gray scale mode. 6-bit dot correction is only available in 10-bit gray scale mode. 16-bit gray scale mode provides 65,536 gray scales for each LED; on the other hand, 10-bit gray scale mode provides 1,024 gray scales. However, in 10-bit gray scale mode, users may flexibly adopt 6-bit dot correction to adjust each LED by 64-step digital dot correction.

In addition, MBI6030 is also embedded with an oscillator as the clock of PWM counter (GCLK) to turn on output ports according to the gray scale data sent from the system controller.

MBI6030’s gray scale mode and the GCLK frequency are set according to the 6-bit header of the input data stream. The following table summarizes the definition of the header.

Summary of the header

Header		Mode	Data Type
H[5:0]	6’b11 111s	16-bit gray scale mode	16-bit gray scale data
H[5:0]	6’b10 101s	10-bit gray scale mode	10-bit gray scale data
H[5:0]	6’b10 011s	10-bit gray scale mode	6-bit dot correction data

bit “s”: 1, high-frequency GCLK (9MHz)

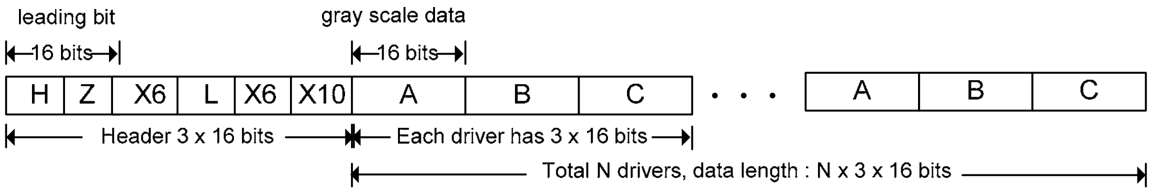
bit “s”: 0, low-frequency GCLK (4.5MHz)

After receiving more than 32 bits of “0”, MBI6030 starts to check the validity of the header, while the input data stream comes out the first bit of “1”. If the header is valid, MBI6030 will latch the specific data according to the following protocol. The header and the protocol are specified below:

16-bit gray scale mode

In the 16-bit gray scale mode, each word is 16 bits. Each MBI6030 uses 3 words (3x16=48 bits) for the gray scale data of $\overline{OUTC}$, $\overline{OUTB}$ and $\overline{OUTA}$. Besides the gray scale data, there is a 48-bit packet header. The whole data format of the 16-bit gray scale mode is shown below:

<u>16-bit gray scale data stream</u>



H[5:0]: 6’b11 111s

bit “s”: 1, high-frequency GCLK

bit “s”: 0, low-frequency GCLK

Z[9:0]: 10’b00 0000 0000

L[9:0]: N-1, N=Number of LED drivers in series

For example, if 1024 LED clusters are connected in series, then L=1024-1=1023, 10’b11 1111 1111.

X6[5:0]: 6 bits, don’t care

X10[9:0]: 10 bits, don’t care

A[15:0]: 16 bits gray scale data for $\overline{OUTA}$. The duty ratio of $\overline{OUTA}$ will be A[15:0]/65536.

B[15:0]: 16 bits gray scale data for $\overline{OUTB}$. The duty ratio of $\overline{OUTB}$ will be B[15:0]/65536.

C[15:0]: 16 bits gray scale data for $\overline{OUTC}$. The duty ratio of $\overline{OUTC}$ will be C[15:0]/65536.

10-bit gray scale mode

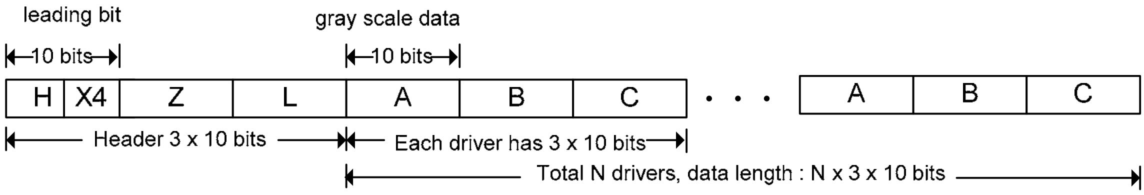
In the 10-bit gray scale mode, users may choose to send or not to send 6-bit dot correction data. The formula of output duty ration is as below:

Duty ratio=(10-bit gray scale)x(6-bit dot correction+1)/65536

If using 6-bit dot correction, users only need to send the dot correction data once. If not using 6-bit dot correction, users do not need to send the dot correction data. The default value of dot correction data is 63 (6b’1).

The 10-bit gray scale data and 6-bit dot correction data are sent separately. The word length in the 10-bit gray scale mode is 10 bits. The data formats of 10-bit gray scale and of 6-bit dot correction are shown below respectively:

10-bit gray scale data stream



H[5:0]: 6'b10 101s

bit "s": 1, high-frequency GCLK

bit "s": 0, low-frequency GCLK

Z1[3:0]: 4'b0000

Z[9:0]: 10'b00 0000 0000

L[9:0]: N-1, N=Number of LED drivers in series

For example, if 1024 LED clusters are connected in series, then L=1024-1=1023, 10'b11 1111 1111

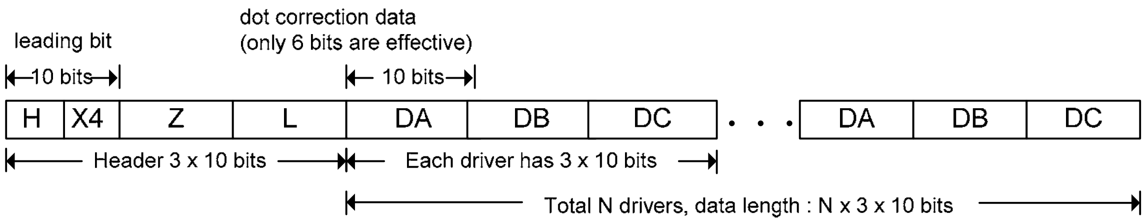
X4[3:0]: 4 bits, don't care

A[9:0]: 10 bits gray scale data for $\overline{OUTA}$

B[9:0]: 10 bits gray scale data for $\overline{OUTB}$

C[9:0]: 10 bits gray scale data for $\overline{OUTC}$

6-bit dot correction data stream



H[5:0]: 6'b10 011s

bit "s": 1, high-frequency GCLK

bit "s": 0, low-frequency GCLK

Z1[3:0]: 4'b0000

Z[9:0]: 10'b00 0000 0000

L[9:0]: N-1, N=Number of LED drivers in series

For example, if 1024 LED clusters are connected in series, then L=1024-1=1023, 16'b11 1111 1111.

X4[3:0]: 4 bits, don't care

DA[5:0]: 6 bits dot correction data for $\overline{OUTA}$

DA[9:6]: unused

DB[5:0]: 6 bits dot correction data for $\overline{OUTB}$

DB[9:6]: unused

DC[5:0]: 6 bits dot correction data for $\overline{OUTC}$

DC[9:6]: unused

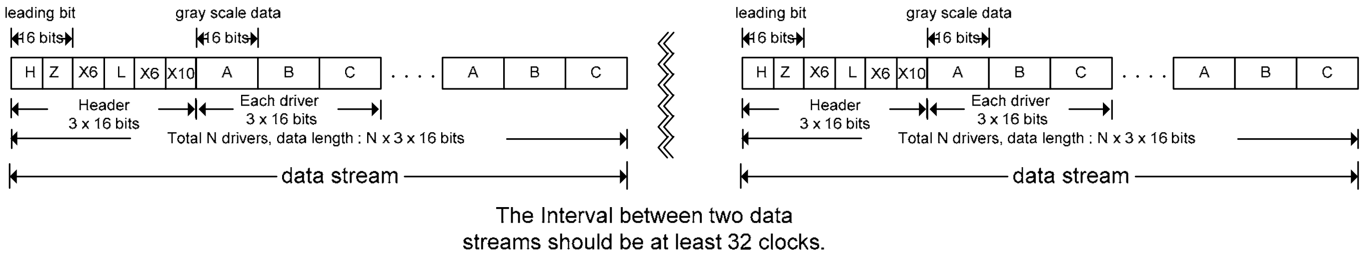
The duty ratio of $\overline{OUTA}$ will be A[9:0])x(DA[5:0]+1)/65536.

The duty ratio of $\overline{OUTB}$ will be B[9:0])x(DB[5:0]+1)/65536.

The duty ratio of $\overline{OUTC}$ will be C[9:0])x(DC[5:0]+1)/65536.

The interval between two data streams

Users need to leave at least 32 clocks interval between two data streams in order to help MBI6030 identify the data stream correctly. The following timing diagram shows the example of the interval between two data streams in 16-bit gray scale mode.



PWM Counting

Designed with S-PWM technology, MBI6030 may increase the visual refresh rate by 64 times. MBI6030 will continuously repeat the PWM cycle and turn on the output ports according to the image data until the next image data is correctly recognized. Once the next input data is correctly recognized, MBI6030 will stop the present PWM cycle and restart a new PWM cycle to show the new data immediately.

16-bit gray scale mode:

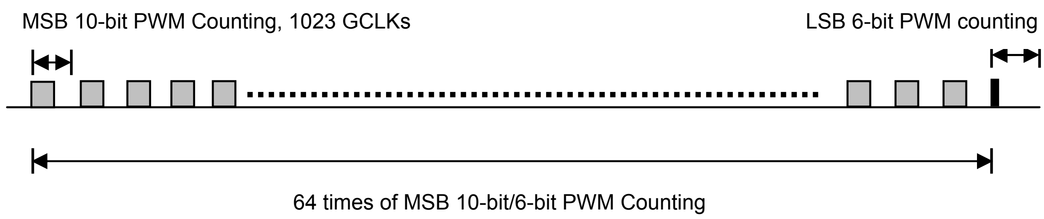
In the 16-bit grays scale mode, MBI6030 scrambles the 16-bit PWM to 64 segments.

So that the visual refresh rate is increased to:

4.5MHz (min. GCLK frequency) / 65536 x 64 = 4,395Hz

If the GCLK frequency is 9MHz, the visual refresh rate will be:

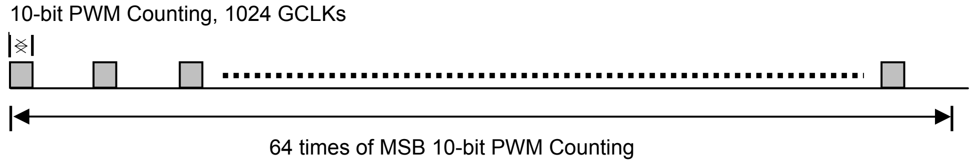
9MHz / 65536 x 64 = 8,789Hz



10-bit gray scale mode:

In the 10-bit gray scale mode, the duty ratio of the output port is (10 bits gray scale data) x (6 bits dot correction data +1)/65536. The 10 bits gray scale data is repeated for (dot correction +1) times. MBI6030 can also increase the visual refresh rate in this mode by the S-PWM technology.

For example, the following figure shows the duty cycle of dot correction data = 31.



Embedded Voltage Regulator

MBI6030 has an embedded voltage regulator to regulate the high input supply voltage to 5V supply voltage for internal and external use. The input voltage is ranging from 7~30V, which is suitable for 12V/24V system. The high supply voltage is connected to VDDH, and the output of the regulator is connected to VDDL. An external capacitor of 4.7uF should be connected between VDDL and ground to stablize the output voltage. MBI6030 can provide 5V power supply from VDDL for peripheral devices when sufficiently biased. There is a thumb rule to estimate the 5V output supply current (I_{DDO}):

If V_{DDH} =12V, then I_{DDO} is around 8mA;

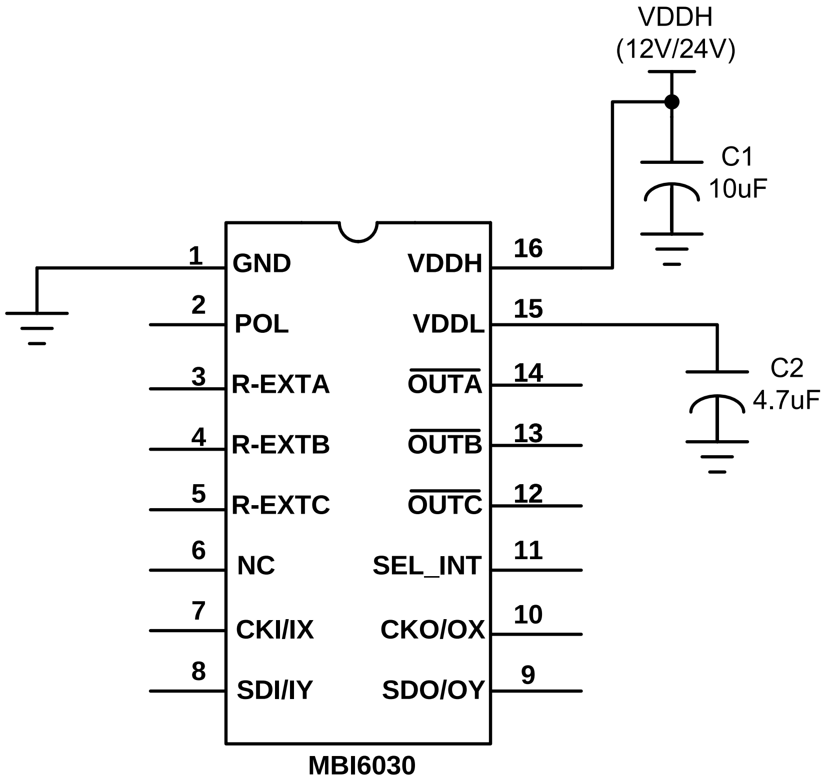
if V_{DDH} =12V, then I_{DDO} is around 16mA.

MBI6030 also supports 5V power supply by connecting the power to both VDDH and VDDL directly. Please refer to the application circuit section or MBI6030 application note for further details on circuit design.

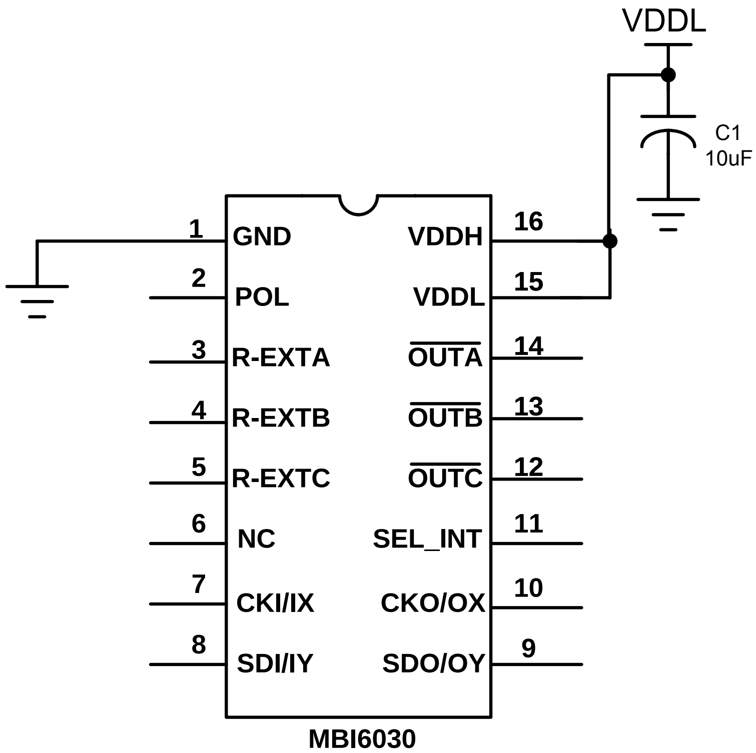
Application Information

Application Circuit

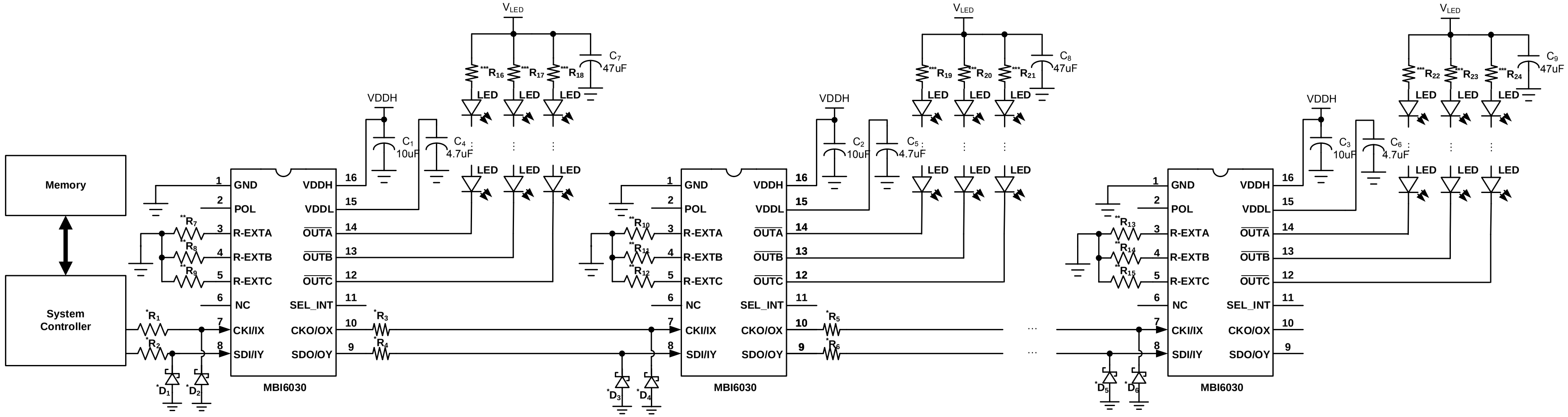
12V/24V Power System



5V Power System



Series Connection



	SPI-Like Interface (CKI/SDI)	Cross Reference Interface (IX/IY)
SEL_INT	Floating	Connected to VDDL

* Add resistors and Schottky diodes to prevent undershoot voltage.

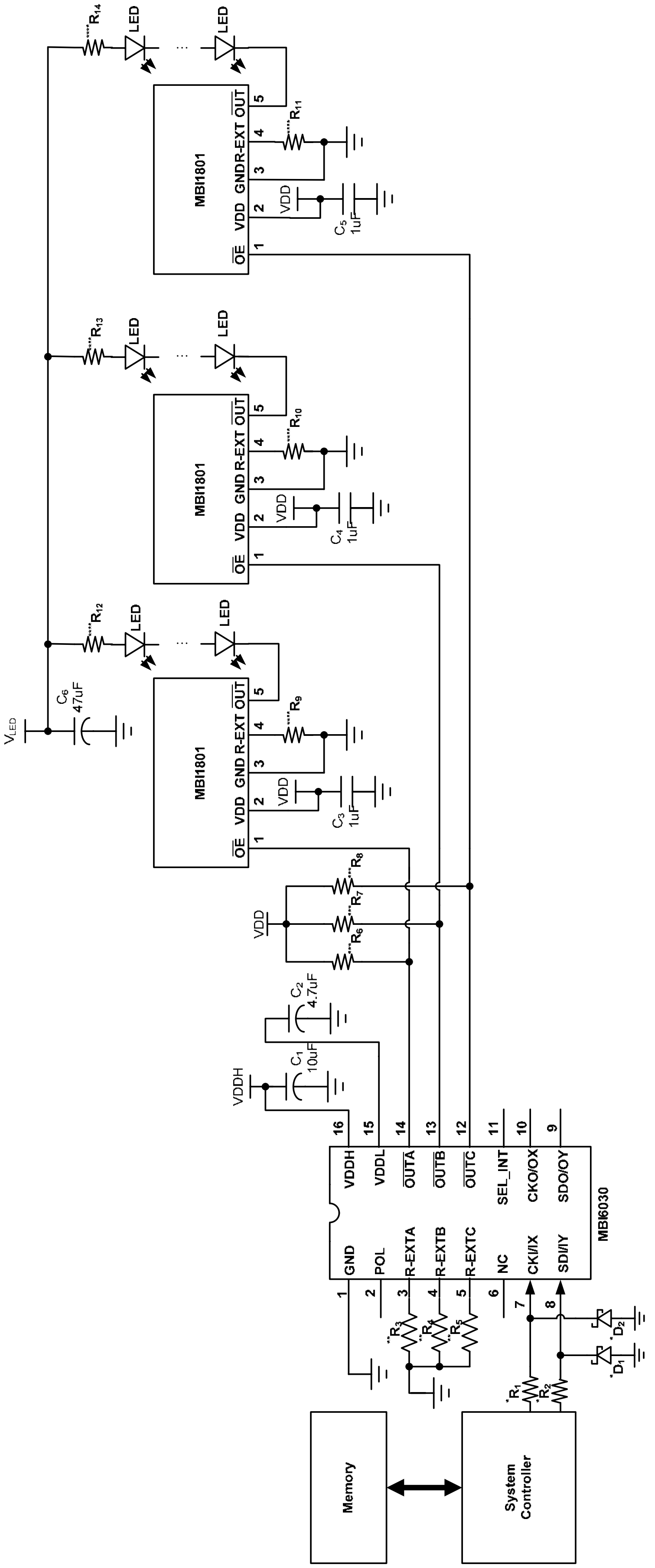
** Please refer to the section of “Adjusting Output Current” of MBI6030 Preliminary Datasheet V1.00.

*** R_{16}~R_{24}=(V_{LED}-V_F-V_{DS})/I_{OUT}

Note:

1. Power supply is connected to VDDH.
2. For hot swapping, system grounding, connector design, and external ESD protection, and please refer to MBI6030 application note for details.

MBI6030 controls 3 x MBI1801



* Add resistors and Schottky diodes to prevent undershoot voltage.

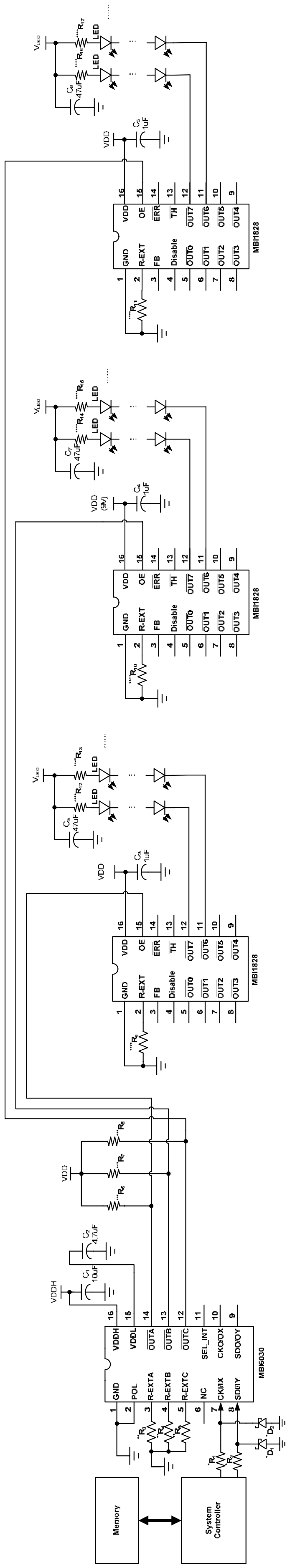
** Please refer to the section of "Adjusting Output Current" of MBI6030 Preliminary Datasheet V1.00.

*** Add pull-up resistors to drive 3 x MBI1801, and $R_6 \sim R_8 = (V_{DD} - V_{DS})/I_{OUT} < V_{IL,OE}$ of MBI1801.

**** Please refer to MBI1801 application note for details.

Note:
1. POL is floating.
2. For hot swapping, system grounding, connector design, and external ESD protection, and please refer to MBI6030 application note for details.

MBI6030 controls 3 x MBI1828



* Add resistors and Schottky diodes to prevent undershoot voltage.

** Please refer to the section of "Adjusting Output Current" of MBI6030 Preliminary Datasheet V1.00.

*** Add pull-up resistors to drive 3 x MBI1828, and R_6~R_8=(VDD-V_{DS})/I_{OUT} < $V_{IL,OE}$ of MBI1828.

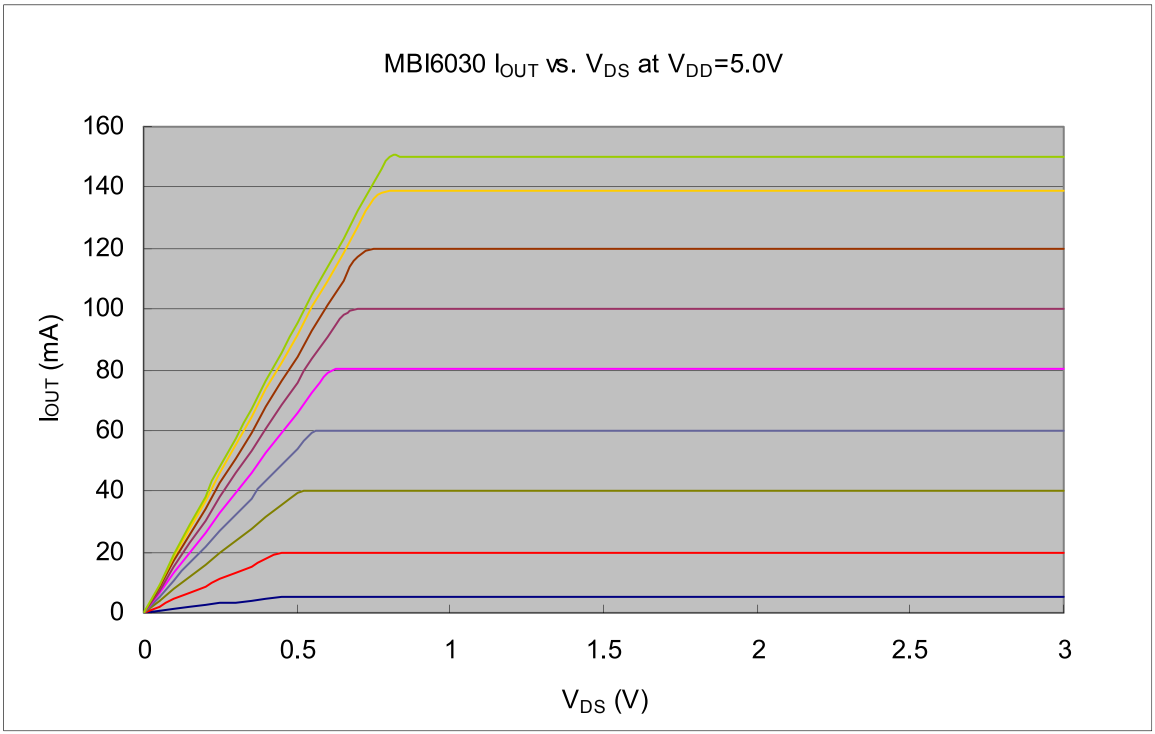
**** Please refer to MBI1828 application note for details.

Note:
1. POL is connected to ground.
2. For hot swapping, system grounding, connector design, and external ESD protection, and please refer to MBI6030 application note for details.

Constant Current

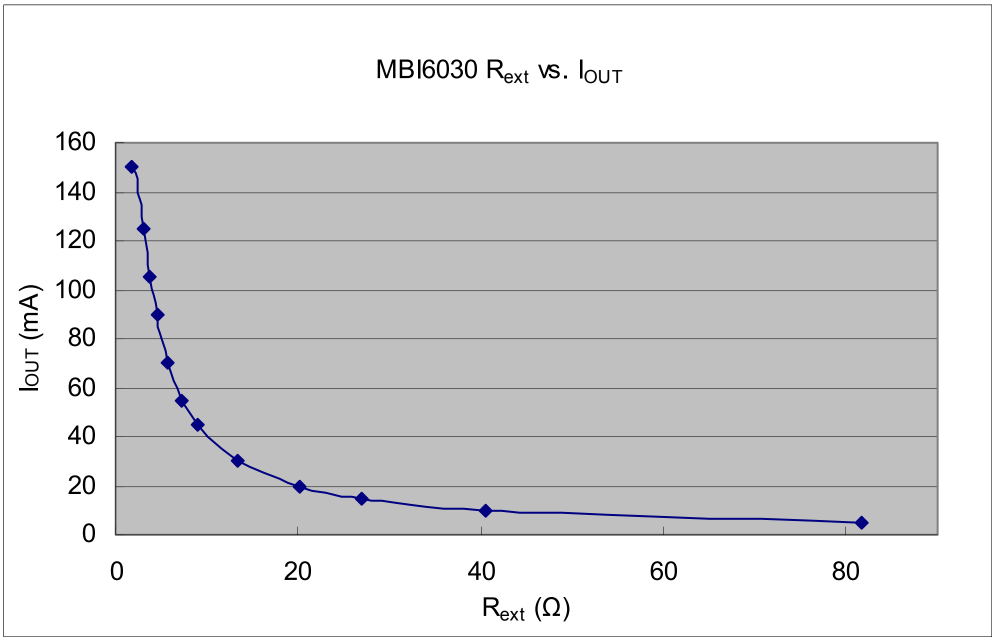
1) MBI6030 performs excellent current skew: the maximum current variation between channels is less than ±3%, and that between ICs is less than ±3%.

2) In addition, in the saturation region, the output current keeps constant when the output voltage (V_{DS}) is changed. . This characteristic guarantees the LED show the same brightness regardless of the variations of LED forward voltages (V_F).



Adjusting Output Current

The output current of each channel (I_{OUT}) is set by an external resistor, R_{ext}. The relationship between I_{OUT} and R_{ext} is shown in the following figure.



Also, the output current can be calculated by the equation:

$I_{OUTA}=V_{REXT}/(R_{extA}+0.116)$

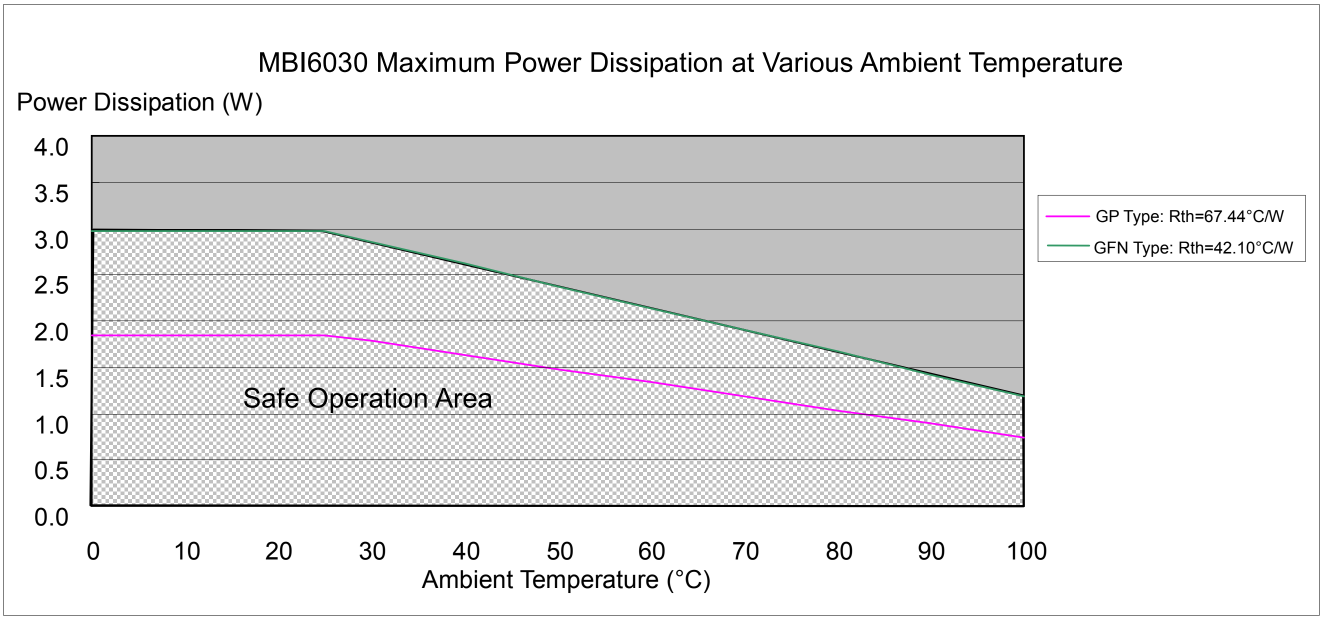
$I_{OUTB}=V_{REXT}/(R_{extB}+0.116)$

$I_{OUTC}=V_{REXT}/(R_{extC}+0.116)$

Where V_{REXT} is around 0.4 V, and R_{extA}, R_{extB}, R_{extC} are the resistances of the external resistors connected to R-EXTA, R-EXTB, R-EXTC terminals. The current (as a function of R_{ext}) is around 97mA when R_{extA}, R_{extB}, or R_{extC}=4Ω, and 19.9mA when R_{extA}, R_{extB}, or R_{extC}=20Ω.

Package Power Dissipation (P_D)

The maximum power dissipation, $P_D(max)=(T_{j,max}-T_a)/R_{th(j-a)}$, decreases as the ambient temperature increases. Please refer to the following figure to design within the safe operation area.



TP Function (Thermal Protection)

MBI6030 will automatically protect IC from overheating when the junction temperature exceeds the threshold, T_X (typ. 155 ^oC). If the POL is pulled up, the output current will be turned off. Thus, the junction temperature starts to decrease. As soon as the temperature is below T_{RECV} (typ. 125 ^oC), the output current will be turned on again. The on-state and off-state switch are at a high frequency; thus, the blinking is imperceptible. However, the average output current is limited, and therefore, the driver is protected from being overheated.

Load Supply Voltage (V_{LED})

The design of V_{LED} should fulfill two targets:

1. Less power consumption and heat
2. Sufficiently headroom for the LED and driver IC to operate in the constant current region.

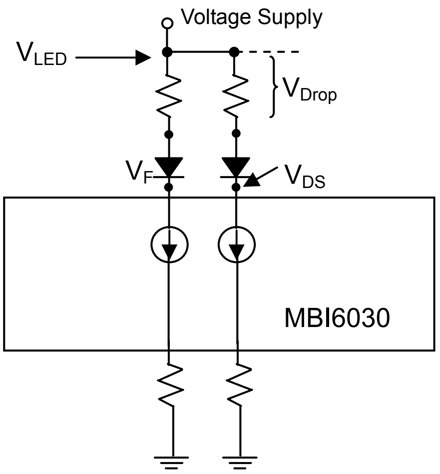
The power dissipation (P_D) of MBI6030 is calculated by the equation:

$P_D=(V_{DDH} \times I_{DD}) + [I_{OUTA} \times (V_{DSA} - V_{REXTA})] + [I_{OUTB} \times (V_{DSB} - V_{REXTB})] + [I_{OUTC} \times (V_{DSC} - V_{REXTC})]$

From the figure below, $V_{DS} = V_{LED} - V_F$, which V_{LED} is the supply voltage of LED. $P_{D\,(act)}$ will be greater than $P_{D\,(max)}$, if V_{DS} drops too much voltage on the driver. In this case, it is recommended to use the lowest possible supply voltage or to set an external resistor to reduce the by V_{DROP}.

$V_{DS}=(V_{LED}-V_F)-V_{DROP}$

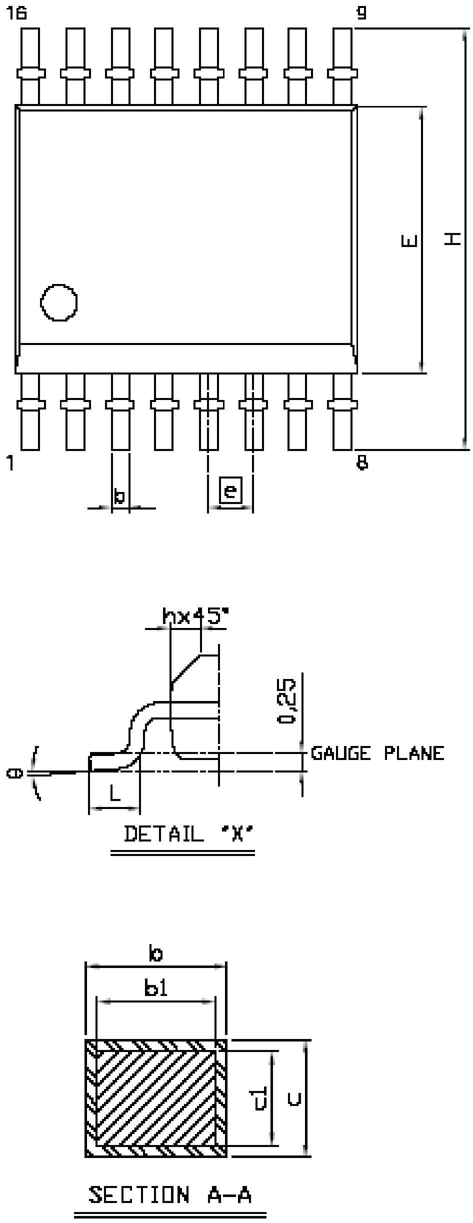
Please refer to the following figure for the application of the resister.

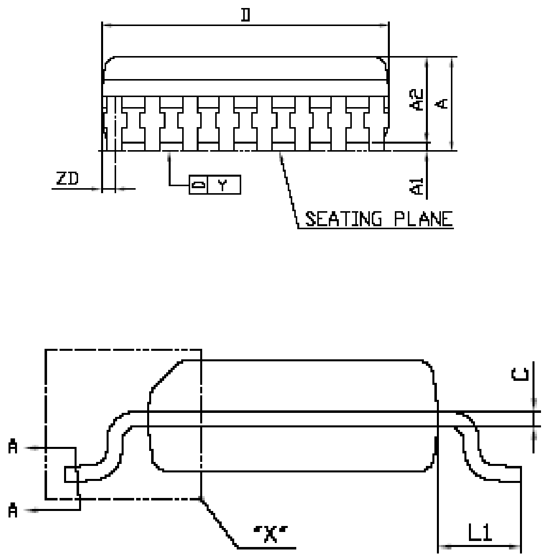


Switching Noise Reduction

LED drivers are frequently used in switch-mode applications which always behave with switching noise due to the parasitic inductance on PCB. To eliminate switching noise, please refer to “Application Note for 8-bit and 16-bit LED Drivers-Overshoot”.

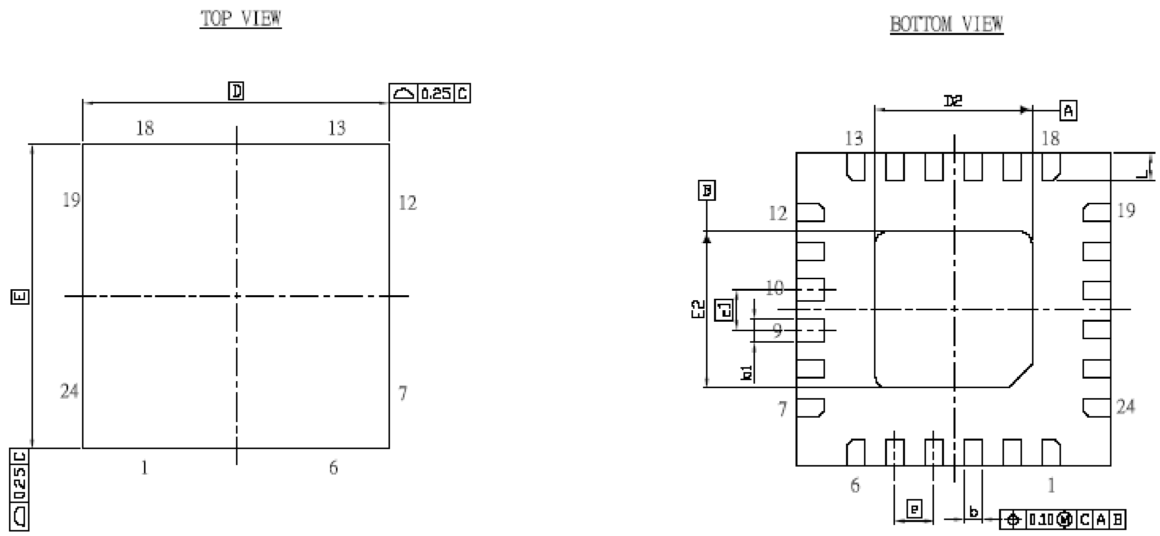
Package Outline

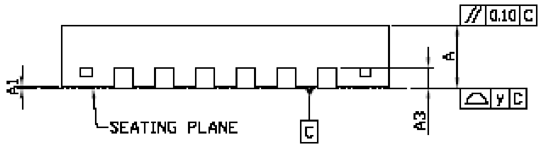




SYMBOL	DIMENSION (MM) MIN.	DIMENSION (MM) NOM.	DIMENSION (MM) MAX.	DIMENSION (MIL) MIN.	DIMENSION (MIL) NOM.	DIMENSION (MIL) MAX.
A	1.35	1.60	1.75	53	63	69
A1	0.10	0.15	0.25	4	6	10
A2	1.40	1.45	1.50	55	57	59
b	0.20	0.254	0.30	8	10	12
b1	0.20	0.254	0.28	8	10	11
c	0.18	0.203	0.25	7	8	10
c1	0.18	0.203	0.23	7	8	9
D	4.80	4.90	5.00	189	193	197
E	3.80	3.90	4.00	150	154	157
e	0.635 BSC			25 BSC		
H	5.80	6.00	6.20	228	236	244
h	0.25	0.42	0.50	10	17	20
L	0.40	0.635	1.27	16	25	50
L1	1.00	1.05	1.10	39	41	43
ZD	0.23 REF			9 REF		
Y			0.075			3
θ	0°		8°	0°		8°

MBI6030GP Outline Drawing

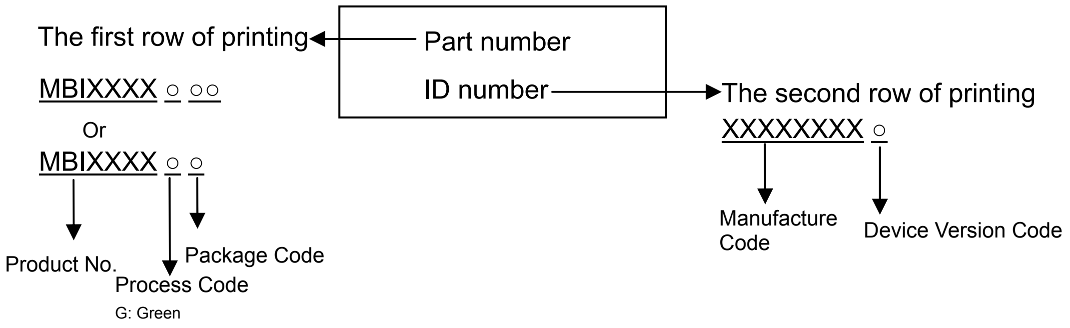




SYMBOL	DIMENSION (MM)			DIMENSION (MIL)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	27.6	29.5	31.5
A1	0	0.02	0.05	0	0.79	1.97
A3	0.203 REF			8 REF		
b	0.18	0.23	0.28	7.1	9.0	11.0
D	3.90	4.00	4.10	153.5	157.5	161.4
D2	1.90	2.00	2.10	74.8	78.7	82.7
E	3.90	4.00	4.10	153.5	157.5	161.4
E2	1.90	2.00	2.10	74.8	78.7	82.7
e	0.50 BSC			19.69 BSC		
L	0.25	0.35	0.45	9.8	13.7	17.7
y	0.08			3.15		
b1	0.25	0.30	0.35	9.8	11.8	13.7
e1	0.52 REF.			20.5 REF.		

MBI6030GFN Outline Drawing

Product Top-mark Information



Product Revision History

Datasheet version	Device version code
V1.00	A

Product Ordering Information

Part Number	RoHS Compliant Package Type	Weight (g)
MBI6030GP	SSOP16L-150-0.64	0.111g
MBI6030GFN	QFN24L-4*4-0.5	0.038g

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